

WHAT IS CLAIMED IS:

1 1. A regulated laser welding apparatus for laser welding a
2 first workpiece and a second workpiece to join the
3 workpieces along a joint, said apparatus comprising:

4 a laser welding device including a laser beam source
5 arranged to be movable in a welding direction along said
6 joint of said workpieces, wherein said laser beam source is
7 further movable with respect to at least one of a location
8 and an orientation thereof relative to said joint of said
9 workpieces, and wherein said laser beam source is adapted
10 to emit a laser beam directed at a weld point on said joint
11 of said workpieces so as to form a weld seam therealong to
12 join said workpieces;

13 a sensor arrangement including a sensor arranged on or
14 near said laser welding device and coupled to said laser
15 welding device so as to move together with or following
16 said laser beam source in said welding direction along said
17 joint of said workpieces, wherein said sensor is directed
18 at said weld seam formed by said laser beam along said weld
19 joint so as to detect actual seam information
20 characterizing at least one of an actual seam position and
21 an actual seam flank angle of said weld seam that is
22 actually formed by said laser beam;

23 a weld seam position regulating arrangement that is
24 connected to said sensor arrangement so as to receive said
25 actual seam information, and that includes a regulating
26 circuit adapted to carry out a comparison of said actual

27 seam information with nominal desired seam information
28 characterizing at least one of a desired seam position and
29 a desired seam flank angle of said weld seam that is to be
30 produced, and to generate a regulating value based on a
31 result of said comparison; and

32 an adjusting device that is connected to said weld
33 seam position regulating arrangement so as to receive said
34 regulating value, and that includes an actuator arrangement
35 coupled to said laser welding device and adapted to adjust
36 at least one of said location and said orientation of said
37 laser beam source relative to said joint of said workpieces
38 in response to and dependent on said regulating value.

1 2. The apparatus according to claim 1, wherein said actual
2 seam information characterizes said actual seam flank
3 angle, and said nominal desired seam information
4 characterizes said desired seam flank angle.

1 3. The apparatus according to claim 1, wherein said actual
2 seam information characterizes said actual seam position,
3 and said nominal desired seam information characterizes
4 said desired seam position.

1 4. The apparatus according to claim 1, wherein said weld seam
2 position regulating arrangement includes an external input
3 connected to said regulating circuit and adapted to receive
4 an externally supplied seam information as said nominal
5 desired seam information.

1 5. The apparatus according to claim 4, wherein said regulating
2 circuit further comprises a memory storing an internal
3 stored seam information as said nominal desired seam
4 information.

1 6. The apparatus according to claim 5, wherein said regulating
2 circuit further comprises a threshold evaluating component
3 that is connected to said external input so as to receive
4 said externally supplied seam information and to said
5 memory so as to receive said internal stored seam
6 information, and that is adapted to carry out an evaluation
7 of said externally supplied seam information relative to a
8 threshold value, and to selectively provide either said
9 externally supplied seam information or said internal
10 stored seam information as said nominal desired seam
11 information in response to and dependent on a result of
12 said evaluation.

1 7. The apparatus according to claim 1, wherein said regulating
2 circuit further comprises a memory storing an internal
3 stored seam information as said nominal desired seam
4 information.

1 8. The apparatus according to claim 1, wherein said regulating
2 circuit comprises a comparator that receives said actual
3 seam information and said nominal desired seam information
4 and carries out said comparison thereof.

1 9. The apparatus according to claim 8, wherein said regulating
2 circuit further comprises a converter component that
3 receives said result of said comparison from said
4 comparator and generates therefrom said regulating value.

1 10. The apparatus according to claim 1, wherein said sensor
2 comprises a sensor head positioned proximate to said weld
3 seam and oriented with a sensing axis thereof directed at
4 said joint.

1 11. The apparatus according to claim 1, wherein said laser beam
2 source is a first laser beam source forming said weld seam
3 as a first weld seam, said laser welding device further
4 comprises a second laser beam source, said first and second
5 laser beam sources are arranged respectively on opposite
6 sides of said first workpiece, said second laser beam
7 source is adapted to emit a second laser beam directed at
8 said weld point on said joint so as to form a second weld
9 seam therealong on an opposite side of said first workpiece
10 relative to said weld seam formed by said laser beam
11 emitted by said first laser beam source, said sensor is a
12 first sensor, said sensor arrangement further comprises a
13 second sensor, said first and second sensors are arranged
14 respectively on said opposite sides of said first
15 workpiece, said second sensor is arranged on or near said
16 laser welding device and coupled thereto so as to move
17 together with or following said second laser beam source in

18 said welding direction along said joint of said workpieces,
19 and said second sensor is directed at said second weld
20 seam.

1 **12.** The apparatus according to claim 11, further comprising a
2 common data line connected to both of said sensors and to
3 said weld seam position regulating arrangement.

1 **13.** The apparatus according to claim 1, wherein said sensor is
2 an optical sensor.

1 **14.** The apparatus according to claim 1, wherein said sensor is
2 a light section sensor that optically detects a geometry of
3 said weld seam to provide said actual seam information.

1 **15.** The apparatus according to claim 1, wherein said weld seam
2 position regulating arrangement comprises a proportional or
3 differential one-way regulator.

1 **16.** A method of laser welding a first workpiece and a second
2 workpiece to join the workpieces along a joint, comprising
3 the steps:

- 4 a) arranging said first workpiece and said second
5 workpiece to be joined along said joint therebetween;
- 6 b) emitting a laser beam from a laser beam source and
7 directing said laser beam at a weld point on said
8 joint;

9 c) moving said laser beam source in a welding direction
10 along said joint to thereby move said weld point along
11 said joint so as to form a weld seam therealong to
12 join said workpieces;
13 d) during said step c), using an optical sensor,
14 optically sensing actual seam information
15 characterizing at least one actual value of at least
16 one physical geometric parameter of said weld seam;
17 e) comparing said actual seam information with nominal
18 desired seam information characterizing at least one
19 nominal desired value of said at least one physical
20 geometric parameter of said weld seam, to produce a
21 comparison result;
22 f) when said comparison result indicates an unacceptable
23 deviation of said actual seam information from said
24 nominal desired seam information, then adjusting at
25 least one of a location and an orientation of said
26 laser beam source to a new adjustment relative to said
27 joint, dependent on and responsive to said comparison
28 result, and continuing or repeating said steps c), d)
29 and e) with said new adjustment of said laser beam
30 source.

1 17. The method according to claim 16, wherein said at least one
2 physical geometric parameter of said weld seam comprises a
3 weld seam flank angle of said weld seam.

1 **18.** The method according to claim 17, wherein said nominal
2 desired value of said weld seam flank angle is in a range
3 from 40° to 50°, and wherein said steps c), d), e) and f)
4 are carried out so that said actual value of said weld seam
5 flank angle is maintained in or brought into a range from
6 40° to 50°.

1 **19.** The method according to claim 17, wherein said step d)
2 comprises optically detecting a surface tangent plane of a
3 surface of said second workpiece and a weld seam tangent
4 that passes through a first intersection of a surface of
5 said weld seam with a surface of said first workpiece and
6 a second intersection of said surface of said weld seam
7 with said surface of said second workpiece, and said step
8 c) further comprises determining said actual value of said
9 weld seam flank angle as an angle enclosed between said
10 surface tangent plane and said weld seam tangent.

1 **20.** The method according to claim 16, wherein said at least one
2 physical geometric parameter of said weld seam comprises a
3 seam position of said weld seam.

1 **21.** The method according to claim 20, wherein said nominal
2 desired value of said seam position is in a range from
3 + 0.3 mm to + 0.5 mm, and said steps c), d), e) and f) are
4 carried out so that said actual value of said seam position
5 is maintained in or brought into a range from + 0.3 mm to
6 + 0.5 mm.

1 **22.** The method according to claim 20, wherein said step d)
2 comprises optically detecting a laser beam entry point at
3 which said laser beam penetrates into said first workpiece
4 on a surface of said first workpiece during said steps b)
5 and c), and optically detecting a surface tangent plane of
6 a surface of said second workpiece, and then determining
7 said actual value of said seam position as a spacing
8 distance between said laser beam entry point and said
9 surface tangent plane.

1 **23.** The method according to claim 16, wherein said adjusting in
2 said step f) is carried out so as to change a beam
3 incidence angle of a beam axis of said laser beam relative
4 to a plane of a surface of said second workpiece.

1 **24.** The method according to claim 23, further comprising
2 optically detecting said beam axis of said laser beam and
3 said plane of said surface of said second workpiece, and
4 then determining said beam incidence angle.

1 **25.** The method according to claim 16, further comprising
2 providing an externally generated or input value as said
3 nominal desired seam information for use in said step e).

1 **26.** The method according to claim 16, further comprising
2 calling up a stored value from a memory as said nominal
3 desired seam information for use in said step e).

1 **27.** The method according to claim 16, further comprising,
2 before said step b), a preliminary step of adjusting at
3 least one of said location and said orientation of said
4 laser beam source to an initial adjustment based on and
5 dependent on said nominal desired seam information.

1 **28.** The method according to claim 16, further comprising, after
2 said step a) and before said step b), an additional step of
3 optically sensing an area of said joint of said first and
4 second workpieces, and determining therefrom said nominal
5 desired value of said physical geometric parameter that is
6 to be provided for said weld seam to be formed.

1 **29.** The method according to claim 16, further comprising
2 obtaining interference value information characterizing an
3 interference that interferes with at least one of said
4 steps b), c) and d), and if said actual seam information is
5 missing or faulty, then substituting said interference
6 value information for said actual seam information in
7 carrying out said comparing in said step e).

1 **30.** The method according to claim 16, wherein said first
2 workpiece is a stiffening stringer and said second
3 workpiece is a flat sheetmetal shell component for
4 fabricating an aircraft fuselage shell.